Brain Mechanisms in Face-Name Memory: Evidence From Event-Related Potentials and Spatial Localization of Brain Activity

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Abstract

Face-name memory is a special kind of memory that includes visual and semantic memory. Existing research suggests that name retrieval is located at the final stage of face recognition, but the exact timing has not been fully investigated. This study used ERPs and a method of spatially localizing brain activity to investigate neural mechanisms underlying face-name memory. Participants were given four tasks: perceiving unfamiliar faces, learning face-name pairs, recalling a name by a face, and recognizing familiar faces but without names. We found that recently learned face-name pairs had the same highly activated brain regions as long-term familiar faces, but the long-term familiar faces exhibit larger amplitudes on the P100 component in the ventral occipital cortex and the N400 component in the thalamus and Gpi. Faces that can be recognized by name elicit a stronger response in the N400 component, particularly in the left hemisphere-dominant thalamus, Gpi, hippocampus, and putamen, compared to faces that are only familiar but not known by name. Results suggest that N400 may represent the retrieval of semantic information related to the name and the depth of retrieval of face-name pairs.

Keywords: face-name memory, face recognition, event-related potentials, N400, localization of brain activity

1 Introduction

Face recognition is likely the most advanced cognitive function of the human brain, and comprehending this function should be a primary scientific objective in the field of psychophysiology and cognitive neuroscience (Rossion et al., 2023). Face-name memory is of considerable importance in the field of face recognition research as well as in the study of Alzheimer's disease. It is an associative memory based on the absence of conceptual connections (Kormas et al., 2020) and involves the interplay of multiple cognitive processes, such as visual and semantic memory (Kozlovskiy et al., 2018), as well as attention, speech, and decision-making (Kozlovskiy et al., 2017; Robinson-Long et al., 2009). However, the spatiotemporal mechanisms of the brain for recognizing and retrieving the corresponding name of a face have not been fully investigated.

Researchers have proposed a number of cognitive models for face recognition (Bruce & Young, 1986; Haxby et al., 2000; Schweinberger & Burton, 2003; Schweinberger & Neumann, 2016). Schweinberger and Neumann (2016) suggested the possible conjecture that name retrieval may be located in the final stage of face recognition and depends on semantic access, because sometimes we can't recall the names of some people, even though they seem familiar. Event-related potential (ERP) studies suggest that the N400, which reaches its maximum amplitude in the central parietal lobe, may be associated with the activation of identity-specific representations of familiar faces (Ambrus et al., 2021; Eimer, 2000; Popova & Wiese, 2022; Pyasik & Vartanov, 2015; Schweinberger & Neumann, 2016; Wiese et al., 2019; Wiese, Anderson, et al., 2022; Wiese, Hobden, et al., 2022; Wuttke & Schweinberger, 2019) and with aspects of semantic processing of faces (Schweinberger & Neumann, 2016). Research at fMRI suggests that face-name recognition involves an extensive cortico-subcortical network (Robinson-Long et al., 2009), including the left prefrontal, parieto-occipito-temporal junction, and hippocampus, with face processing primarily in posterior occipito-temporal cortical areas in the right hemisphere and name processing primarily in anterior temporal areas in the left hemisphere, with the left parieto-subcortical area often considered to be a multimodal convergence area (Joassin et al., 2007).

In this study, by using a new brain activity localization method called "virtually implanted electrode" (Vartanov, 2022; Vartanov, 2023) and focusing on the component N400, we compared the ERPs of brain regions of interest extracted from the memory of recently learned face-name pairs with those extracted from the memory of long-term familiar face-name pairs and compared the ERPs for familiar faces with names and simply familiar faces without knowing names. The purpose is to reveal the ERP mechanisms of name memory for faces and the temporal and spatial mechanisms of the interactions of the brain regions. Also discussed about components N50, P100, N170, P200, N250, and P300.

2 Method

2.1 Participants

The experiment involved 66 participants (mean age = 21.83 years, SD = 3.57), including: 33 females (17 Chinese and 16 Russians) and 33 males (18 Chinese and 15 Russians). All participants were right-handed. The education of all participants was high. All participants could read English. Before the experiment, all Chinese participants did not know the names of Russian celebrities in the stimuli; all Russian participants did not know the names of Chinese celebrities in the stimuli. All participants had no neurological disorders or head injuries; they were not taking antidepressants. This study was conducted in accordance with the Ethical Code of the Russian Psychological Society and Department of Psychology, Lomonosov Moscow State University. All participants gave informed consent to the processing of personal data.

2.2 Stimuli

In order to exclude the effect of the colour of the stimulus pictures and the gender of the faces, black-and-white photographs of male faces were used as stimuli. In all photos, the faces were photographed against a white background, in full-face, with a neutral expression and looking forward. The people in the photos did not have hats, tattoos, piercings, or any other jewellery (earrings, necklaces, etc.) on their faces.

Stimuli were presented to participants both on a computer screen (1080*1080) and (during the learning phase) printed on A4 sheets of paper. English was used for all

experimental materials.

The following types of photos of faces were used:

Faces unknown to participants:

20 photos of faces of Chinese citizens who are not celebrities. All photos are generated by artificial intelligence.

20 photos of faces of Russian citizens who are not celebrities. All photos are generated by artificial intelligence.

Faces known to only one group of participants*:*

10 images of faces of Chinese celebrities. Photos of movie artists who are very well known in China but unknown in Russia were selected.

10 images of faces of Russian celebrities. Photos of movie actors who are well known to Russians but unknown to Chinese citizens were selected.

Faces are known to all participants*:*

10 faces of European and American celebrities. We selected photos of such international celebrities who are well known both in Russia and China. Faces of Caucasian race were used.

2.3 Experimental Design and Procedure

The participant was positioned at a distance of 70 cm from the center of the monitor screen on which the stimuli were presented.

Task 1 – perception of unfamiliar faces (Figure 1, Figure 2). 30 faces unfamiliar to the participants were presented sequentially in random order. These were 10 faces of Russians and 10 faces of Chinese who were not celebrities. And also 10 actors' faces: for Chinese participants, the faces of famous actors in Russia; and for Russian participants, the faces of actors who are famous in China. Each face was presented for 1000 ms, with a 500 ms interval between each two faces, during which a fixation point in the centre of the screen was presented. Each face was presented 10 times, totalling 300 presentations of faces. EEG was recorded. At the moment of face presentation, marks were placed in the EEG for subsequent averaging of ERPs.

Task 2 – learning face-name pairs (Figure 3, Figure 4). Participants memorized the names of 10 actors unfamiliar to them, presented in task 1 (for Chinese participants, there were Russian faces of celebrities and their names; for Russian participants, there were faces and names of Chinese celebrities). The faces and their names were printed on sheets of paper, and the participants viewed them at their own pace as many times as they wished until they had memorized them all. The success of memorization was checked and if participants made mistakes, they memorized them again until without error. The names were written in English (black colour, font Times New Roman). EEG was not recorded in this task.

Task 3 – recalling a name by a face (Figure 5). The participants were presented with a face image on the screen (30 Chinese, Russian, and international (European/American) celebrity faces familiar to the participants were presented sequentially in random order), of which 10 were celebrity faces learned in task 2.

After each face, an inscription containing its name (either correct or incorrect) was presented (black on white background, font Times New Roman, centred on the screen). Each face was presented for 1000 ms, and the name was also shown for 1000 ms. When the name appeared, the participants had to press a key on the keyboard to select whether the name was correct or incorrect. If the face matched the name, the right arrow on the keyboard had to be pressed; if the face did not match the name, the left arrow on the keyboard had to be pressed. Each face was presented 10 times for a total of 300 presentations. EEG was recorded. At the moment of face presentation, marks were placed in the EEG for subsequent averaging of event-related potentials.

Task 4 – recognition of familiar faces (Figure 6). Participants were presented with photos of faces (40 faces were presented sequentially in random order, 20 of which were faces that were presented in task 1 but not studied in task 2 and not presented in task 3; and 20 were previously unpresented faces of people unknown to the participants (10 Chinese and 10 Russians)).

After each face was presented, participants were asked whether or not they had seen the face before. Each face was presented for 1000 ms, and the question of familiarity was also

shown for 1000 ms. When the question appeared, participants had to press a key on the keyboard. If they had seen the face before, the right arrow on the keyboard was pressed; if they had not seen the face before, the left arrow was pressed. Each face was presented 10 times, for a total of 400 presentations. The EEG was recorded. At the moment of face presentation, marks were placed in the EEG.

2.4 Equipment and Data Analysis

Stimuli were presented using the Presentation program (version 20.2 of Neurobehavioral Systems, Inc., USA). Monopolar recording of brain activity was done with a 19-channel electroencephalograph called "Neuro-KM" (Company Statokin, Russia). Two reference electrodes were placed on the mastoids, and the electrodes were organized in accordance with the international 10-20% system. The BrainSys program (BrainWin, Russia) was used to exclude artefacts.

Subsequently we employed a novel technique for localizing brain activity known as the “virtually implanted electrode,” which was proposed by Vartanov (2022). It was demonstrated that this technique offers notable benefits with regard to spatial localization (Vartanov, 2023).

Activity was investigated at 53 sites picked from the MNI152 atlas in the centre of the following structures: Hypothalamus, Brainstem, Mesencephalon, Medula Oblongata, Caput n.Caudati L, Caput n.Caudati R, Globus Pallidus Medialis L, Globus Pallidus Medialis R, Putamen L, Putamen R, Thalamus L, Thalamus R, Hippocampus L, Hippocampus R, Corpus Amygdaloideum L, Corpus Amygdaloideum R, G.Cingulate Medialis, Anterior Cingulate BA32, Insula L BA13, Insula R BA13, Ventral Striatum BA25, Dorsomedial prefrontal cortex BA9 L, Dorsomedial prefrontal cortex BA9 R, Supramarginal gyrus BA40 L, Supramarginal gyrus BA40 R, Parietal cortex BA7 L, Parietal cortex BA7 R, V1 BA17 L, V1 BA17 R, Broca BA44 L, Wernicke BA22 L, BA44 R, BA22 R, Cerebellum L, Cerebellum R, Angular G.BA39 L, Angular G.BA39 R, Middle Frontal BA10 L, Middle Frontal BA10 R, Orbital Frontal BA47 L, Orbital Frontal BA47 R, V4 L, V4 R, V3v L, V3v R, VO1 L, VO1 R, VO2 L, VO2 R, PHC1 (OFA) L, PHC1 (OFA) R, PHC2 (FFA) L, PHC2 (FFA) R. Based on

the localization of EEG activity, the technique of averaging ERPs over the full group of participants with an estimate of the 95% confidence interval was carried out. For each of these structures, an integral index of the average signal amplitude (standard deviation) was calculated over the entire period of EEG recording under each of the conditions under study, and correlation coefficients between all pairs of these structures were calculated as an index of functional connectivity. At the same time, "effective" (i.e., causal) connections were studied by looking for the delay (latency shift) of ERPs in one structure against ERPs in the other. This allowed the direction of causal linkages to be determined based on the fact that activity changes occurred first. As a result, comparison graphs of connectivity between the analysed structures were created.

3 Results

3.1 Behavioural Results

3.1.1 Behavioural Results in Task 3 – Recalling a Name by a Face

The average percentage of correct answers without "miss" for participants who performed the task of recalling a name by a face, i.e., "hit", was 84.44% > 50%.

3.1.2 Behavioural Results in Task 4 – Recognition of Familiar Faces

The average percentage of correct answers without "miss" for participants who performed the task of recognition of face familiarity, i.e., "hit", was 76.6% > 50%.

3.2 Results of Event-Related Potentials

3.2.1 Figures of Connectivity and ERPs for Recently Learned Face-Name Pairs and Long-Term Familiar Face-Name Pairs

In task 3 – recalling a name by a face, each participant recalled names for two types of faces – recently learned and long-term familiar faces. The ERPs of all participants (both Russians and Chinese) were averaged, and the following ERPs were obtained:

LRN – recently learned faces (for Russians – faces of Chinese celebrities who have just learned, for Chinese – faces of Russian celebrities who have just learned)

OLD – long-term familiar faces (for Russians – familiar Russian and European/American celebrities, for Chinese – familiar Chinese and European/American

celebrities)

As can be seen from the comparative oriented connectivity graph of the brain structures studied (Figure 7), VO1 R, VO1 L, and VO2 L are the three areas that were strongly activated in both conditions, with P100–200 amplitudes of 10–12 μV. Regions that play an important role in face recognition and name retrieval were also activated: cerebellum, FFA R, hippocampus, putamen, thalamus, the internal globus pallidus (Gpi), etc.

When looking at the figures of ERPs (Figure 8), in some areas that were initially activated (VO1 L, VO1 R, VO2 L, OFA R), ERPs in the left and right hemispheres were outwardly similar, respectively, with significant differences in the amplitude of the P100 component and greater amplitude in long-term familiar faces. Among subsequently activated areas, the N170 component was pronounced in the cerebellum and the FFA R area, but there were no significant differences in amplitude for all components. ERPs in the hippocampus, cerebellum, thalamus, and Gpi were outwardly similar, but there were no significant differences in component amplitudes in the hippocampus and cerebellum; there were no significant differences in the amplitudes of early components in the thalamus and Gpi, but there were significant differences in the N400 component, with the long-familiar face eliciting a larger amplitude.

In summary, there were no differences in the strongly activated brain structures between recently learned and long-term familiar faces, the joint activation of VO1 R, VO1 L, VO2 L could correspond to ERP components P100-P200; in ERP amplitude, the difference in the early component (P100) was significant and the difference in the late component was insignificant in brain structures activated first (VO1 etc.); the difference in each component was nonsignificant in brain structures activated immediately after (FFA R etc.); and in the last brain structures activated (thalamus, Gpi), the difference in the early component was nonsignificant, whereas the difference in the late component (N400) was significant. All differences were that long-term familiar faces elicited larger amplitudes.

3.2.2 Figures of Connectivity and ERPs for Unfamiliar Faces, Familiar Faces With Names, and Familiar Faces Without Names

Tasks 1, 3, and 4 showed unfamiliar faces, familiar faces with known names, and faces that are familiar but not known by name. The ERPs for each of the three conditions were averaged to obtain the following ERPs:

UNF – unfamiliar faces (all faces in task 1)

F+N – familiar faces with names (all faces in task 3)

F-N – familiar faces without names (faces in task 4 that were shown in task 1)

Notably, “F+N” and “F-N” differed in the brain structures that were significantly activated (Figure 9). As can be seen from the comparative oriented connectivity graph of the brain structures examined, VO1 R, VO1 L, and VO2 L were the three regions that were highly activated in both conditions, with P100 amplitudes up to 10–12 μV. V4 R (P100 amplitude up to 9 μV) and the right hemisphere Gpi (P300 amplitude up to 5 μV) are two areas that are strongly activated during “F-N”. There are also areas that play important roles: both parts of the thalamus, both parts of the hippocampus, and the right side of the putamen. In addition, the activation of the left part of the hippocampus to the right part of the putamen differed significantly between the two conditions: the correlation coefficient for “F+N” was 0.62 at a latency of 7 ms, and the correlation coefficient for “F-N” was 0.97 at a latency of 6 ms, suggesting that the putamen is activated faster when “F-N” are activated. However, the dorsomedial prefrontal cortex inhibited the thalamus, Gpi, and putamen, with inhibition of the putamen differing between the two conditions.

In figure 10 of ERPs, in the first activated areas (primary visual cortex, VO1 L, VO1 R, VO2 L, OFA R), the two familiar faces had an outward similarity, with the N50 component induced in both hemispheres, and a significant difference in the P100 component in the right hemisphere, with greater amplitude in the face with a name. Next, two negative components located between 100 and 200 ms were induced: the N140 and N170 components, with a larger amplitude for faces without names. In the areas activated afterwards (V4 L, V4 R, ventral striatum, both parts of the thalamus, both parts of Gpi, both parts of the hippocampus, both sides of putamen), it can be seen that the EPs of both begin to separate in the late component and that there is a significant difference in the N400 component in both

hemispheres, "F+N" having a larger amplitude. In addition, the P100 component in area V4 R had a larger amplitude of evoked "F-N", while there was no significant difference in the N170 component; there were significant differences in the N250 component in the left thalamus and left hippocampus, with a larger amplitude in the case of individuals with names; and significant differences in the P300 component in the ventral striatum, both parts of the thalamus, both parts of Gpi, the left side of the hippocampus and both parts of putamen, with greater amplitude in "F-N".

In the case of unfamiliar faces, as shown by the comparative oriented connectivity graph (Figure 11), their activation was not as extensive as in the case of familiar faces, but VO1 R, VO1 L, and VO2 L were still three areas that were strongly activated, with P200 amplitudes up to 10-11 μV (Figure 10). Among the important structures activated by them, the P100 component in both hemispheres differed significantly from familiar faces, with amplitudes in the order of "F+N", "F-N", "UNF"; the difference in N170 amplitude was significant in V4 L, the left thalamus and both sides of the pale globe, and was larger in unfamiliar faces; the P200 component in the primary visual cortex of the left hemisphere and in VO2 L differed significantly from familiar faces, with larger amplitudes in unfamiliar faces. The N250 component, evoked in the right hemisphere in an area of significant activation, did not appear to be significant with unfamiliar faces compared to familiar faces, but was located rather in a straight line. In the N400 component, the left and right thalamus, Gpi, and left hippocampus reflected a clear separation of the three conditions: faces with known names, unfamiliar faces, and familiar faces without known names, in ascending order of amplitude.

In summary, among familiar faces, VO1 R, VO1 L, and VO2 L, which are significantly activated together on faces with and without names, may correspond to the P100 component; faces without names additionally significantly activate V4 R, which may correspond to the P100 component, and the right side of Gpi to the P300 component; faces without names are activated faster. Regarding ERP amplitudes, in the first activated areas (VO1, etc.), the early components N50 and P100 had larger amplitudes for faces with names, and N140 and N170 had larger amplitudes for faces without names; in areas activated later

(thalamus, etc.), N250 and N400 had larger amplitudes for faces with names, P300 for faces without names, and there were no significant differences in the N170 component. Relatively fewer brain regions were activated in the case of unfamiliar faces, the strongly activated VO1 R, VO1 L and VO2 L probably corresponded to the P200 component; the P100 component was larger in amplitude in the case of familiar faces, the N170 component in both hemispheres and the P200 component in the left hemisphere have larger amplitude for unfamiliar faces, and the N250 component was not evident in the activation area of unfamiliar faces. The more pronounced N400 components in the thalamus, Gpi, and hippocampus of the left hemisphere had the largest amplitude for familiar and known names, the second largest for unfamiliar faces, and the smallest for familiar but unknown names.

4 Discussion

4.1 Recently Learned Face-Name Pairs and Long-Term Familiar Face-Name Pairs

According to the methodology of this study, of interest are differences in the brain areas that are highly activated on the two ERPs, differences in the time delay of activation, the inhibitory nature of activation between brain areas, and differences in the amplitude of the ERPs.

First of all, we wonder whether memory retrieval differs for the two types of memory for face-name pairs, the newly learned (short-term memory) and the long-term familiar (long-term memory)?

In the task of recalling a name from a face, in general, the retrieval process passes through the cerebral cortex and then converges on subcortical structures.

No significant differences were found in the brain regions that were activated when recalling the name of a recently learned face versus the name of a long-term familiar face, suggesting that they utilized the same cortical-subcortical structural network (there were no qualitative differences) and that differences in amplitude may have reflected differences in depth of processing during retrieval of long-term versus short-term memory (there were quantitative differences). Early in the memory retrieval process, P100 differences were significant in the ventral occipital lobe, possibly indicating the onset of deep retrieval of

long-term memory for faces starting at 100 ms; the differences disappeared in the middle period, reflecting a simultaneous spatial and depth form of information processing; late N400 differences were significant in subcutaneous structures – the thalamus, the Gpi – that are involved in cognitive processing (Navid et al., 2022) and possibly in retrieving names from long-term memory when the depth of processing again becomes more profound (Kutas & Federmeier, 2000).

4.2 Unfamiliar Faces, Familiar Faces With Names and Familiar Faces Without Names

According to the face recognition scheme of Schweinberger and Neumann (2016), name retrieval is at the very late stage of recognizing familiar faces, so next we need to find out how does recognizing faces for which the name is known differs from the late stage of recognizing faces for which the name is unknown but just familiar?

Based on the results of the present study, when recognizing faces with and without names, firstly, the inhibitory effect of the dorsomedial prefrontal cortex on the thalamus, Gpi, and putamen appears to reflect the high complexity and cognitive conflict of the task (Clairis & Lopez-Persem, 2023). Secondly, hippocampus and putamen have been shown to be important for memory (Driscoll et al., 2024; Packard, 1999; Sadeh et al., 2011) and may interact (Poldrack & Packard, 2003). In the absence of a name, the left hippocampus activated the right putamen faster, suggesting that processing and retrieval of nameless memories is faster, while processing names involves more effort on the part of the brain and the use of more cognitive resources. Human names exhibit a low occurrence rate, allow for endless variations of sounds, lack inherent meaning, are randomly linked to faces, cannot be mentally visualized, and do not have numerous connections to facial features (Kormas et al., 2020). As a result, they slow down the rate of activation. Thirdly, the additional high V4 R activation at 100 ms for faces without names is an intermediate processing step in the lateral visual pathway important for object recognition, perceptual decision making, and higher-order behavior (Pasupathy et al., 2020), whereas the pale globe has been linked to cognitive function and working memory (Barón-Quiroz et al., 2021), and the additional high activation of the right Gpi at 300 ms of additional increased activation may be related to working

memory (Donchin, 1981; Linden, 2005; Polich et al., 2007). Therefore, the activation of both areas may indicate the activation of information in the participants' working memory that is very pertinent to the experimental tasks.

In terms of activation time series, the P100 component in the first activated areas was larger in faces with names, perhaps reflecting deeper processing, and N170 was larger in faces without names, perhaps reflecting recognition of the person in relation to the task; in subcutaneous structures, N250 and N400 were larger in faces with names, perhaps reflecting name retrieval and deeper processing, and 400 ms or so may be just the right amount of time to distinguish between named and unnamed information.

After familiar face recognition has been discussed, what is the difference between the ERPs elicited when recognizing unfamiliar and familiar faces?

Early activation of the N50, large amplitude of the P100 component on familiar faces may mean that the brain has already sensed familiarity (Förster et al., 2020), although this is not consistent with the findings of some studies (Marzi & Viggiano, 2007; Abreu et al., 2023), it may be due to differences in the stimulus material used in the experiment and in the task. Significant activation of the P200 component (Latinus & Taylor, 2006; Schweinberger & Neumann, 2016) in the ventral occipital lobe in regions VO1 R, VO1 L, and VO2 L during unfamiliar face recognition, as well as significant activation of the N170 component (Cheng & Pai, 2010; Schweinberger & Neumann, 2016) mainly in subcutaneous structures, may imply processing of facial identity features, whereas familiar faces do not require deeper processing because they are already familiar. The N250 component increases significantly on familiar faces (Wiese, Hobden, et al., 2022; Wiese et al., 2023). In the N400 component, the separation into three groups was more pronounced in the thalamus, Gpi, and hippocampus of the left hemisphere (Salisbury & Taylor, 2012; Vigneau et al., 2011): amplitudes were from largest to smallest: faces with known names, unfamiliar faces, and familiar faces without known names. Interestingly, if the N400 component reflected only familiarity (Ambrus et al., 2021; Wiese, Hobden, et al., 2022), unfamiliar faces should have the lowest amplitude, but this was not the case in our results, suggesting that the component may reflect not only

familiarity but also the retrieval of semantic information about the name (Barrett & Rugg, 1989; Schweinberger & Neumann, 2016), which is consistent with our assumptions in the previous discussion.

To summarize, the retrieval of information from both long-term and short-term memory for face-name pairings activates the same network of brain regions. However, long-term memory retrieval involves more extensive processing, as indicated by the activation of the P100 in the ventral occipital cortex, the N400 in the thalamus, and the Gpi of the right hemisphere. Faces that are associated with names provide more detailed information compared to faces that are only familiar but not known by name. The process of recognizing faces that are familiar but not known by name is slower and involves deeper processing. In the left hemisphere dominated subcortical structure, particularly in the thalamus, Gpi, hippocampus, and putamen, there is a late negative component (N400) that may indicate the retrieval of semantic information related to names. The perception of known faces is detected in the primary visual cortex and ventral occipital cortex, starting from the early phases of face recognition (N50, P100, N250). On the other hand, the perception of unfamiliar faces requires additional processing of facial features (N170, P200).

5 Conclusion

Our work offers further evidence for the retention of face-name associations. The successful retrieval of face-name memory is strongly associated with the activation of N400 components, particularly in the thalamus, Gpi, hippocampus, and putamen. The N400 component may indicate the retrieval of semantic information related to the name, as well as the level of retrieval of face-name pairs.

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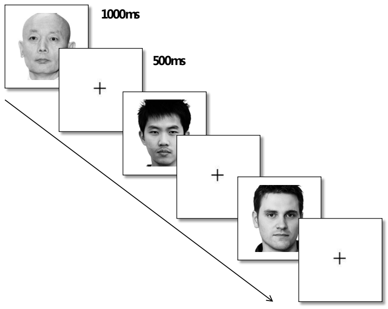
Figure 1

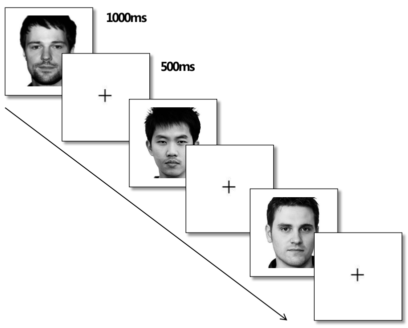
Examples of Faces Shown to Russian Participants in Task 1



Note. From left to right, famous Chinese face, unfamiliar Chinese face, unfamiliar Russian face.

Figure 2

Examples of Faces Shown to Chinese Participants in Task 1



Note. From left to right, famous Russian face, unfamiliar Chinese face, unfamiliar Russian face.

Figure 3

Examples of Faces of Famous Chinese Actors With Corresponding Names Learned by Russian Participants in Task 2

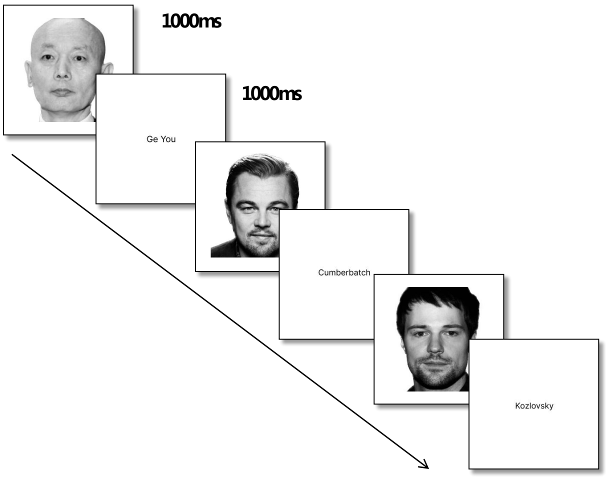
Figure 4

Examples of Faces of Famous Russian Actors With Corresponding Names Learned by

Chinese Participants in Task 2

Figure 5

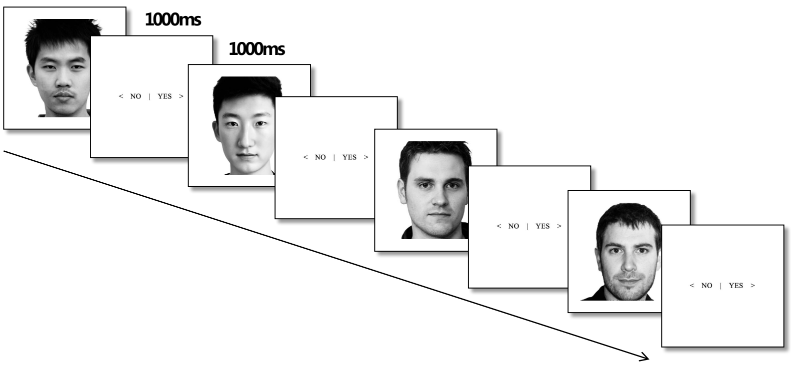
Examples of Faces and Names of Celebrities That Were Shown to Participants in Task 3



Note. From left to right, famous Chinese face, name (right); famous American face, name (wrong); famous Russian face, name (right).

Figure 6

Examples of Faces and Questions That Were Shown to Participants in Task 4

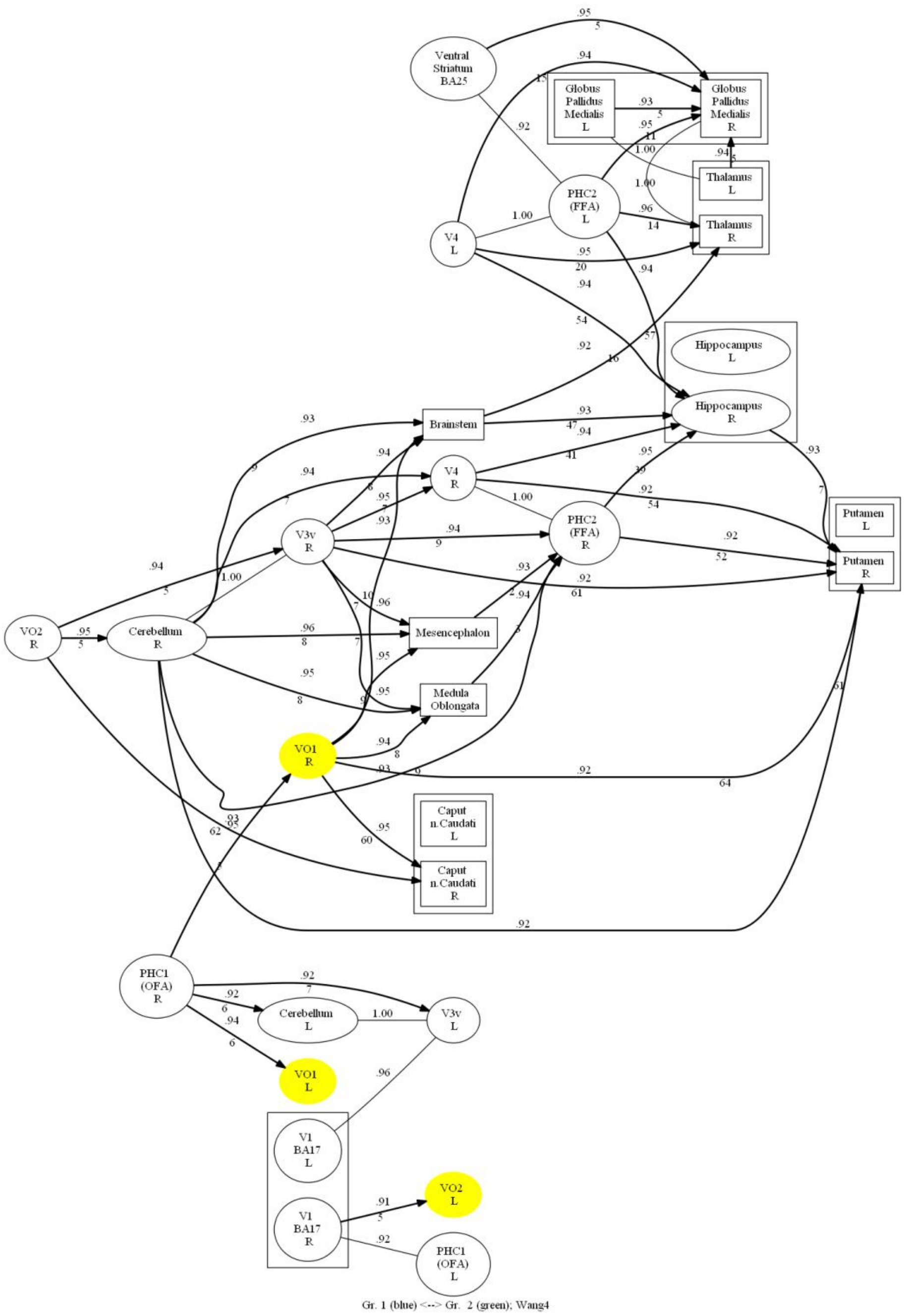


Note. From left to right, familiar Chinese face, question (Yes); unfamiliar Chinese face,

question (No); familiar Russian face, question (Yes); unfamiliar Russian face, question (No).

Figure 7

Comparative Oriented Connectivity Graph of the Studied Brain Structures for Recently Learned Face-Name Pairs (LRN) and Long-Term Familiar Face-Name Pairs (OLD)

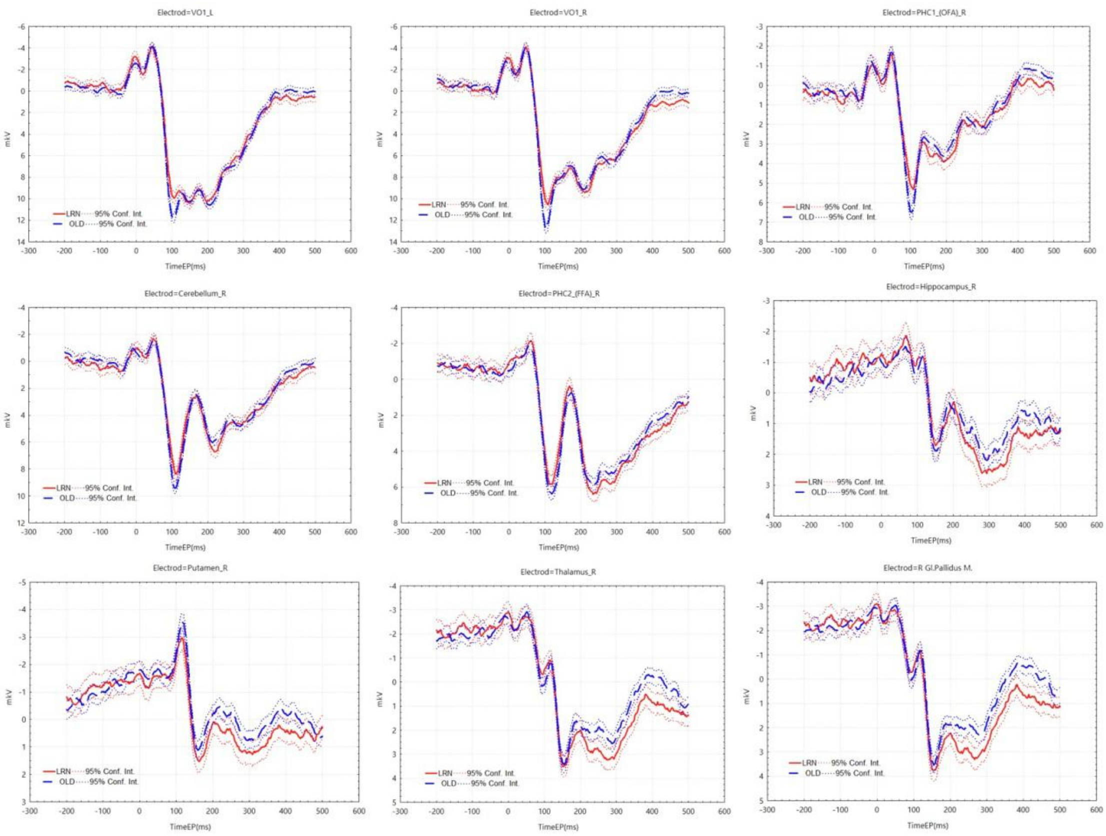


Note. Here and below, black connecting lines indicate overall positive correlation, dashed lines indicate inhibition (negative correlation), and arrows indicate causation; circles represent cortical structures, squares represent subcortical or connecting left and right

structures; yellow indicates all groups of highly activated areas, blue indicates the first group, and green indicates the second group.

Figure 8

ERPs for Recently Learned Face-Name Pairs (LRN) and Long-Term Familiar Face-Name Pairs (OLD)



Note. Here and below, the corresponding 95% confidence intervals are presented in small dotted lines. On the horizontal axis, time in ms; on the vertical axis, amplitude in µV.

Figure 9

Comparative Oriented Connectivity Graph of the Studied Brain Structures for Familiar Face with Name (F+N) and Familiar Face Without Name (F-N)

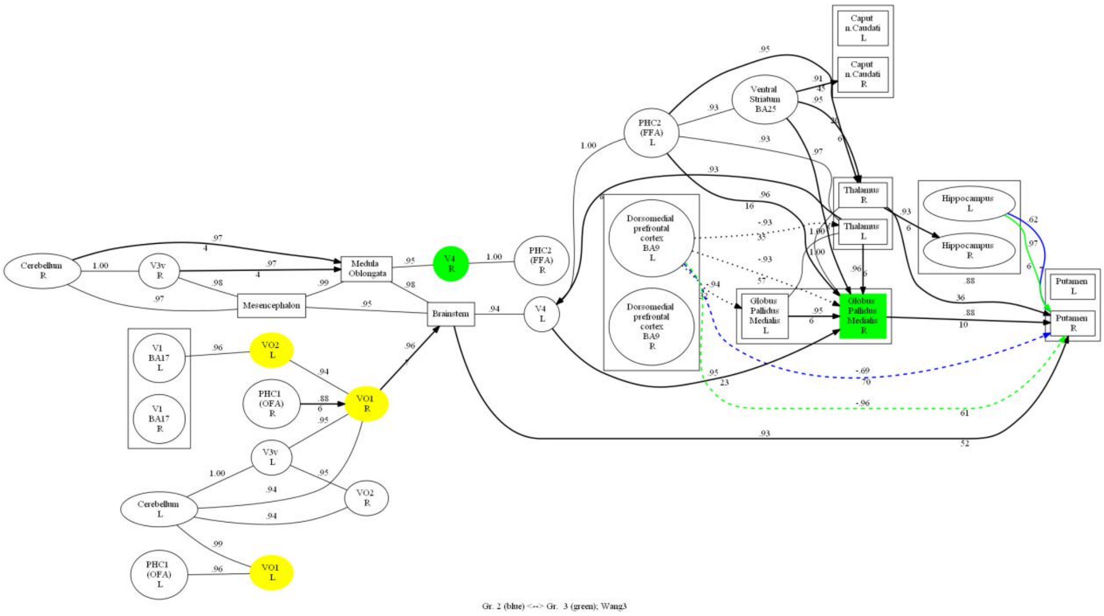
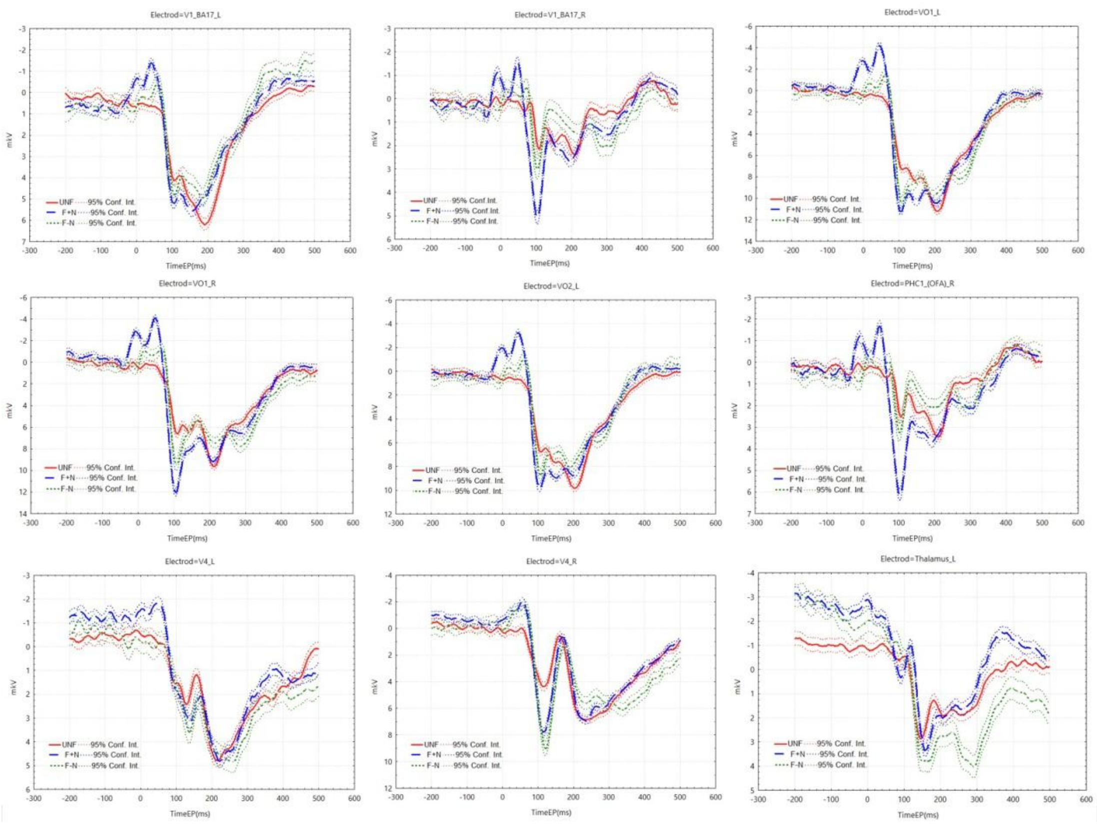


Figure 10

ERPs for Unfamiliar Face (UNF), Familiar Face With Name (F+N) and Familiar Face Without Name (F-N)



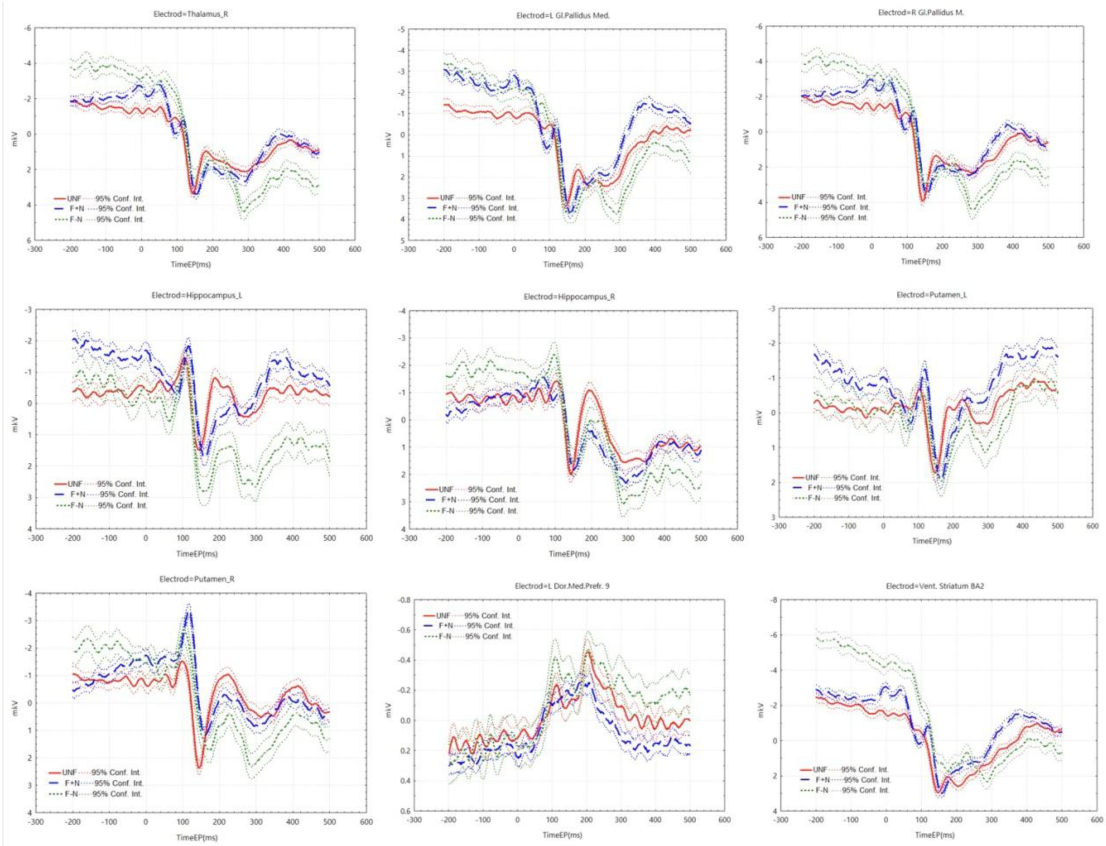
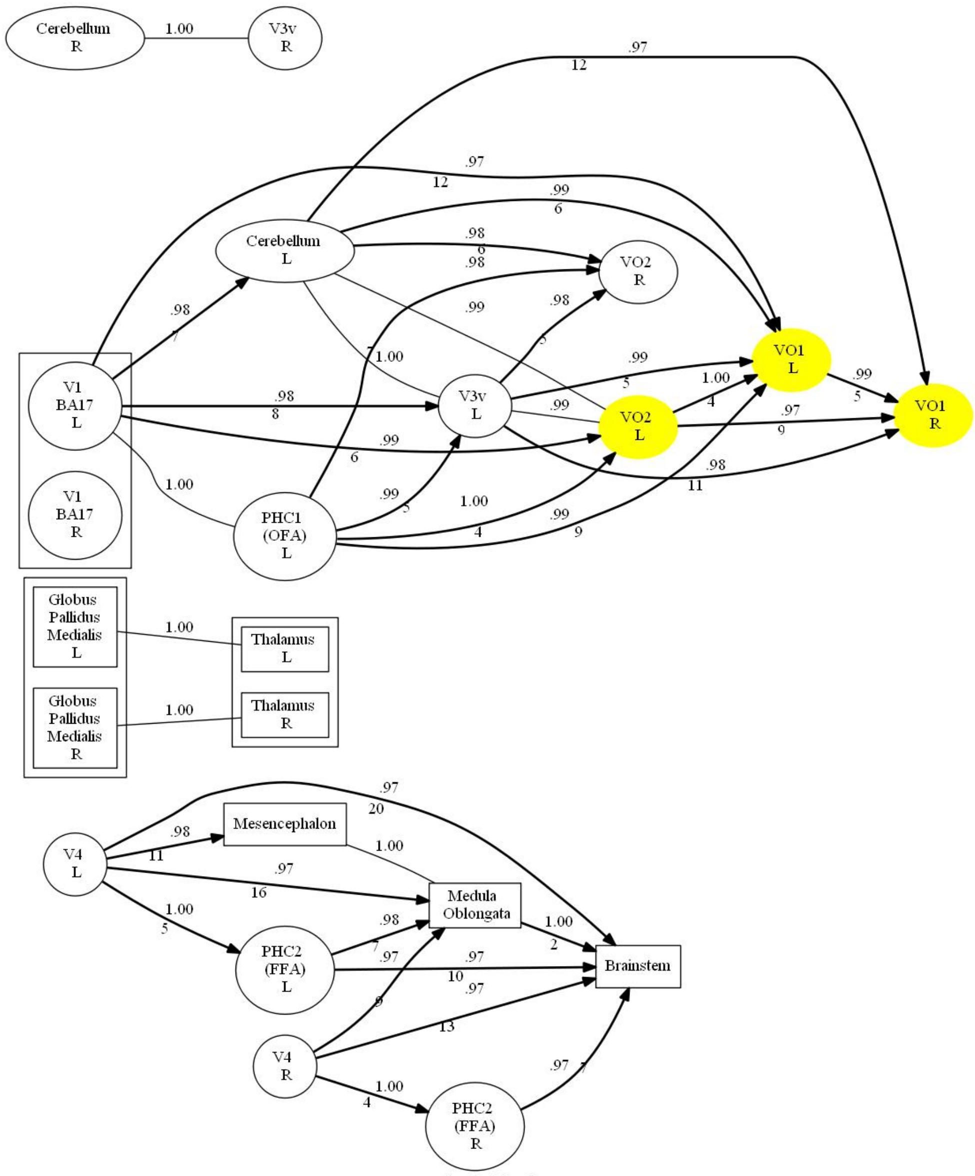


Figure 11

Comparative Oriented Connectivity Graph of the Studied Brain Structures for Unfamiliar Face (UNF)


Cerebellum R
V3v R
Cerebellum L
VO2 R
V1 BA17 L
V1 BA17 R
V3v L
VO1 L
VO2 L
VO1 R
PHC1 (OFA) L
Globus Pallidus Medialis L
Globus Pallidus Medialis R
Thalamus L
Thalamus R
V4 L
Mesencephalon
Medula Oblongata
PHC2 (FFA) L
Brainstem
V4 R
PHC2 (FFA) R

Gr. 1; Wang3.